NetApp Private Cloud Capacity Planning Guide

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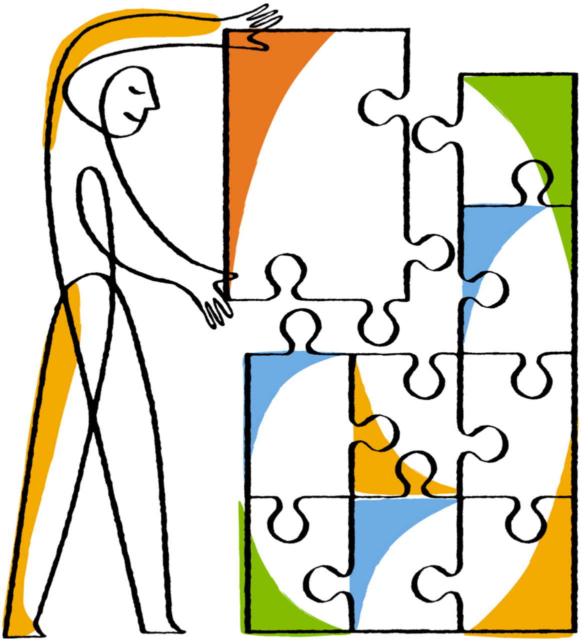

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Executive Summary

This guide is designed to help organizations quickly develop and implement private cloud infrastructures while reducing both cost and risk.

Private Cloud Infrastructure Capacity Planning Introduction

In general, cloud computing enables customers to efficiently provision resources on demand in a self-service model. Resources such as CPU, memory, storage capacity, and performance are optimized in the cloud through resource pooling. Resource pooling allows physical and virtual resources to be dynamically reassigned according to the customer's current and future demands.

A private cloud infrastructure is operated solely for an organization. It can be managed by the organization or a third party and can exist on or off site. Although private cloud infrastructures can be thoroughly agnostic in terms of hardware and software, NetApp® storage efficiency technologies can be used to increase performance.

NetApp refers to each instance of hardware as a pod, and each pod is designed to be fully self-contained, if necessary. Although each customer's environment can vary in its exact configuration, after the private cloud infrastructure is built, it is easily scalable when requirements and demands change. This includes vertical scaling (adding additional resources within a pod), as well as horizontal scaling (adding additional pods). Examples of vertical scaling include:

- Deploying additional or different rack-mount servers, blades, and chassis to increase compute capacity
- Deploying additional disk shelves to improve input/output (I/O) capacity and throughput
- Adding special hardware or software to introduce new features

The NetApp Private Cloud Infrastructure Capacity Planning Guide provides a blueprint for a successful private cloud deployment by aligning sizing and provisioning models into one consolidated, easy-to-use methodology.

Capacity Concepts

Capacity planning relies on workloads, resource pools, and a capacity budget. Workloads in IT environments generally fall into two categories: characterized workloads and uncharacterized workloads. Effective capacity planning requires a basic understanding of these distinct workloads.

Characterized Workloads

Characterized workloads are well studied, well understood, and well defined. Characterized workloads are generally associated with major applications that have wide adoption rates. In general, because the workload is well known and well understood, precise sizing tools already exist for characterized workloads.

This document focuses on uncharacterized workloads. For characterized workloads, NetApp recommends working with your storage and application providers to accurately size workloads with the available tools. Contact your NetApp sale representative for information about characterized workload sizing.

Uncharacterized Workloads

Uncharacterized workloads vary widely and are neither well defined nor well understood. In general, no capacity planning or sizing tools are available for uncharacterized workloads. Both public and private cloud general-purpose virtualized client and server workloads tend to fall into the uncharacterized category.

A wide variety of virtual machine (VM) workloads exist, which makes it difficult to prescriptively define resource pools to support them. The resource consumption of a virtual desktop, for example, is not the same as the resource consumption of a departmental Microsoft® SharePoint® server. NetApp private cloud capacity planning divides the varying workloads into a relatively small number of buckets or VM classes. NetApp uses the terms small, medium, large, and extra large to define VM classes, for example:

- Virtual desktops or small infrequently used application servers are considered small VMs.
- A wide variety of infrastructure roles, such as Microsoft Active Directory® servers, are considered medium VMs.
- Departmental applications leveraging Microsoft SQL Server® and departmental SharePoint servers are examples of large VMs.
- Large online transaction processing (OLTP) workloads such as Oracle® Real Application Clusters (RAC) are considered extra large VMs.

Note: At this scale, it is likely that the workload is in fact a characterized workload and should be sized independently by using the dedicated tools for such workloads.

The following table summarizes the resources required for each VM class.

Table 1: Example resources per VM class.

Small VM	Medium VM	Large VM	Extra Large VM
1 CPU	2 CPUs	4 CPUs	8 CPUs
1GB RAM	4GB RAM	12GB RAM	24GB RAM
60GB disk capacity	100GB disk capacity	500GB disk capacity	1TB disk capacity
25 IOPS	80 IOPS	200 IOPS	400 IOPS

Note: In *VM Sizing per Resource Pool* on page 15, these numbers will be used to demonstrate how to determine the number of each VM size that can be hosted according to each of the four resource pools.

Service Levels

Levels of service define the expectations for recovery time objective (RTO) (how long it takes to recover an environment after a disaster), recovery point objective (RPO) (the amount of data loss that is acceptable in the event of a disaster), and backup intervals.

Unlike public clouds, private clouds benefit from value-added services to manage disaster recovery (DR) and business continuity. Organizations that implement service plans to manage DR and continuity may also consider integrating VM-level backup services. NetApp defines levels of service in terms of platinum, gold, silver, and bronze.

Table 2: Service-level critical statistics for disaster recovery.

Class	RPO	RTO	Maximum VMs
Platinum	0–15 minutes	30 minutes	30
Gold	1 hour	2 hours	120
Silver	12 hours	24 hours	Unlimited
Bronze	N/A	N/A	Unlimited

Note: NetApp MetroCluster™ is required to achieve a zero-minute RPO. Contact your NetApp sales representative for details.

Table 3: Service-level critical statistics for backups.

Class	RPO	RTO	Backup Retention
Platinum	1 hour	15 minutes	• 24 hourly backups • 7 daily backups • 2 weekly backups
Gold	4 hours	15 minutes	• 6 hourly backups • 7 daily backups • 2 weekly backups
Silver	24 hours	30 minutes	• 7 daily backups • 2 weekly backups
Bronze	24 hours	N/A	• 7 daily backups • 2 weekly backups

The duration of backup and restore operations is affected by the number of VMs. The level of service determines how many VMs you can place on a VM datastore. Smaller datastores restore more quickly than larger ones. Similarly, large numbers of VM datastores on a node increase the RTO. In most cases, a mixture of VM classes is required to maximize the efficiency of your hardware. For example, at the gold level of service, a set of small VMs quickly fill up a server, because only 30 VMs can be placed on any single node at the platinum level of service. However, at that level the hardware would not reach capacity with only 1GB of RAM and 1 CPU per VM.

Platinum Service Level

The platinum level of service is for customers with critical applications without which the business cannot survive, such as shopping carts, billing mechanisms, and sales support. These environments have tight RPOs for which almost no data loss is acceptable. Similarly, RTOs must be brief: no longer than 30 minutes. Due to the higher cost, a smaller percentage of workloads fall into this service-level category relative to the gold and silver service levels.

Gold Service Level

The gold level of service is for customers with applications that can afford to lose a small amount of data, but that are still important to the functioning of the business. RPOs may be from 15 minutes to an hour and have RTOs of 2 hours.

Silver Service Level

The silver level of service is for customers with applications that are important to the business, but are not critical, and the temporary loss of which does not unduly affect the business. RPO for the silver level of service may be up to 12 hours and an RTO of 24 hours.

Bronze Service Level

The bronze level of service is for any data that is not important to the day-to-day running of the business, such as personal web hosts or development build servers. These servers carry no disaster recovery requirement, because they can be rebuilt if they are lost. The servers are still backed up, but only as long as the prior tiers' services levels are being met.

Resource Pools

Within shared infrastructures, resources are managed by grouping similar resources together into resource pools.

A public or private cloud resource can be compute (CPU or memory), storage (performance or capacity), or bandwidth (both external for client connectivity and internal for connectivity between VMs or between VMs and other resources, such as storage). The combination of these resource pools is the basis of a resource budget.

Capacity Planning Methodology

Capacity planning relies on defining a set of resource pools that when combined become the resource budget.

Characterized workloads are sized using usual processes and tools, and the result is subtracted from the resource budget. What remains is applied to uncharacterized workloads. This methodology categorizes uncharacterized workloads into averaged buckets, which are then subtracted from the resource budget.

Resource Budget

There are many types of resources within a public or private cloud environment. For the purposes of this guide, the network capabilities are assumed, and we focus our attention instead on compute and storage resource types.

Compute Resources

There are two general categories of compute resources: CPU and memory. When you create VMs on a hypervisor, decide early how much CPU and RAM to give the VM.

To optimize private cloud infrastructures, it is important to balance resource pools and increase efficiency. Oversubscribing hardware, or fanning out, helps to balance resource pool utilization. When you oversubscribe processing resources, you set up a fanned-out environment in which no single resource operates at 100% capacity. Rather, an ideal fan-out ratio creates an environment like a time share in which individual resources within the group operate at 40% to 70% utilization to account for failover and burst capacity.

NetApp supports most virtualization technologies on the market, and the guidance provided here is widely applicable and can be adapted as necessary. However, this document focuses primarily on Microsoft Hyper-V® and VMware vSphere®.

All hypervisors use the concept of logical processors to define CPU resources. A logical processor can have either a physical or a hyperthreaded core. It is generally acceptable to count a hyperthreaded core as half a physical core. Therefore, if a physical blade has 2 sockets with 6 cores each and hyperthreading is enabled, then the physical blade is said to contain 18 logical processors, 12 physical cores, and 6 hyperthreaded cores. After the number of logical processors is known, fan-out ratios are applied to determine how many virtual processors can be supported in total.

Although Microsoft Hyper-V has no logical CPU limit, NetApp recommends a starting maximum fan-out ratio of 8:1 for server workloads and 12:1 for virtual desktop infrastructure (VDI) workloads. As of the time of this writing, VMware vSphere 5.5 supports a maximum fan-out ratio of 32:1; however, NetApp recommends a starting maximum of 8:1 for server workloads and 12:1 for VDI. These values are merely suggested starting points; actual fan-out ratios should be determined by monitoring ready time to make sure that all running VMs are satisfied. If a low ready time is observed, the ratio can be safely increased. A high ready time indicates that the ratio should be decreased. A conservative starting point for fan-out ratios is 4:1 for servers and 6:1 for VDI.

Generally speaking, most hypervisors support two methods for memory allocation: fixed or thin. Using the fixed method, all of the allocated RAM is fully assigned and removed from the available pool. When using fixed allocation, you cannot oversubscribe the memory resources.

The thin method allocates memory at the host level as it is consumed by VMs. This enables you to oversubscribe the physical resources of the host. Thin memory allocation systems should be used to increase VM density; they are not a means to increase the available memory pool. In general, a safe oversubscription ratio of 2:1 can be implemented.

Some hypervisors enable additional memory efficiency through methods such as transparent page sharing, which is the equivalent of memory deduplication and/or a more tunable memory-allocation subsystem. Regardless of hypervisor, you must decide whether or not to oversubscribe memory resources.

> **Note:** When oversubscribing memory, do not exhaust the available physical resources, or prohibitive performance impacts will result.

Remember, not all hypervisors are the same. Therefore, analyze your requirements to determine the appropriate fan-out ratio for your private cloud infrastructure.

Storage Resources

Storage resources are broadly categorized in terms of storage performance and storage capacity.

Capacity refers to the amount of data that can be stored on a disk. Performance refers to input/output operations per second (IOPS, which refers to how quickly data can be read or written) and latency (how long it takes to process a single data request).

From a sizing perspective, capacity utilization can affect performance. No storage pool should ever be filled to 100% utilization. NetApp recommends 20% free space to account for unexpected growth and technologies such as volume-level NetApp Snapshot™ copies.

Random-access workloads often place significant demands on the throughput of individual disk drives. Systems must be configured with enough disk drives to meet the IOPS and latency needs of the applications, even if this results in excess capacity. NetApp recommends that customers mitigate any potential capacity and performance imbalances by purchasing disks with performance that is appropriate for the desired latency of operations that are not serviced from cache or by implementing the appropriate virtual storage tiering (VST) technologies, such as NetApp Flash Pool™ or NetApp Flash Cache™.

Relationship Between Storage and Service Levels

When defining storage resource pools, it is desirable to have more than one storage pool, each with its own unique capacity and performance characteristics. Representative workloads for the extra-large VM class, for example, might include databases with high transaction rates such as enterprise resource planning (ERP) or OLTP. Representative applications include Oracle and SAP®. These workloads typically exhibit a high write/read ratio, but also exhibit a high write/overwrite ratio.

> **Note:** Overwrite is the replacement of an existing block of storage with new data, versus the additional write of a new block.

Typically, extra-large VM workloads fall into the characterized class and should be sized independently on dedicated storage. Extra-large workloads can still be virtualized and placed into the shared cloud. However, using the general storage pools for such workloads could prematurely exhaust either capacity or performance.

Typically, large VM workloads utilize high-performance applications, are often latency sensitive, and need less than 10ms latency. SAS drives with Flash Pool for read and overwrite acceleration provide the lowest cost performance that satisfies the need for fast retrieval and overwrite of frequently accessed blocks with low latency.

The medium VM class generally makes up the majority of the cloud infrastructure. These workloads have a roughly equal 50/50 read/write ratio. Average latency should be less than 15ms, with acceptable peaks up to 20ms. High-speed SAS drives with Flash Cache for read acceleration provide the lowest cost performance that satisfies the need for fast retrieval of frequently accessed blocks.

The small VM class is only applicable to nonessential workloads such as web servers, desktops, and so forth. Due to the low performance requirements, the average latency should be less than 20ms, with acceptable peaks up to 40ms. SATA drives with Flash Cache for read acceleration provide the lowest cost capacity that satisfies the need for fast retrieval of frequently accessed blocks.

Unfortunately, there are no well-defined rules for storage, but certain approaches can be used. Depending on the size and scope of the cloud infrastructure, as well as the anticipated VM deployments, it might make sense to have multiple, separate, dedicated pools. Likewise, it might be more fiscally responsible to run a single pool using quality of service (QoS) to control how much performance each VM is allowed to consume. Generally speaking, though, NetApp has the tools and technologies to help build any pool at a fraction of the cost, all while enabling IT to combat shadow IT by offering value-added services, such as backup and DR, at a fraction of what such solutions would cost in the public cloud.

How Capacity Planning Works

Within shared infrastructures, when any one resource pool—such as CPU, RAM, IOPS, or storage capacity—is exhausted, the entire cloud is exhausted. Therefore, to design a well-balanced environment, the environment should be sized so that resources are consumed at approximately the same rate.

To determine system capacity, create containers that represent compute resources (CPU and RAM) and storage resources (IOPS and disk capacity). Apply modifiers to the raw resource numbers to account for overprovisioning, and create templates that represent the amount of allocatable resources. The environment can then be sized from any one of four perspectives: memory, CPU, storage capacity, or storage performance. To assess your environment, you must calculate utilization from all four perspectives to make sure that no single resource pool is exhausted prematurely.

> **Note:** The numbers used in the following equations are for example only. You must determine the number of resources required based on the features supported in your unique private cloud infrastructure.

Calculate Compute Resources

To calculate compute resources, determine the sum of the CPU cores for all servers and multiply by the oversubscription or fan-out ratio. Determine the physical processor core count by taking the number of cores per socket, and then multiply by the number of sockets. For example, a two-socket quad-core host would have eight physical cores. Generally speaking, it is acceptable to count hyperthreading as half a core per thread, in which case, a 2-socket quad-core with hyperthreading enabled would have 12 physical cores.

Use the following formula to calculate the total logical CPU count:

```
physical cores × fan-out ratio = logical CPU count
```

Calculate Memory Resources

Memory resources can be calculated for fixed or thin provisioning. For fixed provisioning, the total amount of memory resources is the sum of the physical RAM. To determine the amount of provisionable RAM when using thin provisioning, the total amount of physical RAM is multiplied by the oversubscription or fan-out ratio.

Use the following formula to calculate the memory resources for thin provisioning:

```
total physical RAM × fan-out ratio = logical RAM count
```

Calculate Storage Resources

Provisioning storage is slightly more complex. A drive has two separate resource pools: capacity and performance (IOPS). Overall storage capacity is extinguished when one of those resources is exhausted before the other. There is a natural imbalance on a drive between IOPS and capacity. Therefore, to avoid isolating capacity or IOPS, determine the more critical storage resource and overprovision based on that.

Depending on the type of drive in use, either IOPS or capacity will be scarce. For example, a large SATA drive typically has a large capacity but only a small amount of performance that can be allocated. Therefore, SATA drives are better suited for large data warehouse and other low-performance applications. In contrast, SSDs have a comparatively small amount of capacity, but a large amount of performance; in this case, capacity is the scare resource.

To mitigate the imbalance, determine the GB:IOPS ratio for your storage pool and allocate resources based on that ratio. When one resource is provisioned, an amount according to the GB:IOPS ratio of the opposing resource is also allocated. This can be difficult to predict due to virtual storage tiering (VST) technologies and their ability to artificially inject performance into the storage pool.

To determine the GB:IOPS ratio, ascertain the projected IOPS capacity (accounting for performance accelerators, such as Flash Pool or Flash Cache) and the projected GB capacity (accounting for NetApp storage efficiency technologies, such as deduplication and compression).

In the absence of formal NetApp sizing assistance, use the following assumptions:

- Storage efficiency of 50% (or .5)
- Performance acceleration of 100% (or 2)

  Note: If you are not using Flash Cache or Flash Pool, assume a performance accelerator of 20% (or .2)

Use the following formula to calculate the GB:IOPS ratio:

```
[physical capacity × (1 + storage efficiency)] ÷ (physical IOPS ×
performance accelerator) = GB:IOPS ratio
```

The GB:IOPS ratio is used during provisioning to maintain a balance between the two resources. The preceding formula yields the number of GB per one IOPS and will most commonly be more than a 1:1 ratio unless you're using an all-flash storage controller.

Calculate Provisionable VM Count

After the total capacity of the compute, memory, and storage resource pools is determined, the provisionable VM count can be calculated by combining the VM class with the service level to determine the resource needs per VM. After a per-VM resource requirement is established, the total provisionable VM count can be derived by dividing the per VM resource by the available resource pool on a per–resource pool basis. The smallest number in the following set of equations is the maximum number of VMs that can be safely hosted:

- Maximum VMs = sum pCPU ÷ desired number of vCPU per VM

  Note: pCPU is physical CPU.

- Maximum VMs = sum pRAM ÷ desired RAM per VM

Note: pRAM is physical RAM.

- Maximum VMs = total IOPS ÷ (desired GB per VM × IOPS per GB)
- Maximum VMs = total GB ÷ (desired IOPS per VM × GB per IOPS)

Practical Examples

The numbers used in the following equations are for example only.

Determine the number of resources required for your environment by using the methods described in *How Capacity Planning Works* on page 12. Assume a FlexPod® environment has 8 hosts with 24 physical CPUs (pCPUs) each (or 2 × 12 core CPUs with hyperthreading) and 192GB of RAM. The storage is configured with 5 shelves (118 disks) of 10k RPM 900GB SAS drives and 1 shelf of 10 200GB SSDs to create Flash Pool aggregates. Using this example, the following equations demonstrate how to calculate the available resources.

Calculate Compute Resource Pool

1. Calculate the physical cores:
   ```
   (24 pCPUs + 12 hyperthreaded CPUs per host) × 8 hosts = 288 pCPUs
   ```
2. Calculate the logical CPU count:
   ```
   288 pCPUs × 4 = 1152 logical CPUs
   ```
   Note: Assume a 4:1 overcommit ratio.

Calculate Memory Resource Pool

1. Calculate the physical RAM:
   ```
   192GB per host × 8 host = 1.5TB of pRAM
   ```
2. Calculate the logical RAM:
   ```
   1.5TB × 1.5 = 2.25TB logical RAM
   ```
   Note: Assume a 50% overcommit ratio.

Calculate Storage Capacity Pool

1. Calculate the capacity:
   ```
   88 disks × 900GB per disk = 77TB storage
   ```
   Note: Some drives have been removed to account for parity and spares.
2. Calculate the provisionable capacity:
   ```
   77TB storage × 1.5 = 115TB storage
   ```

Note: Assume storage efficiency of 50%.

Calculate Storage Performance Pool

1. Calculate the raw IOPS:
   `88 disks × 140 IOPS per disk = 12,000 disk IOPS`
2. Calculate the provisionable IOPS capacity:
   `12,000 IOPS × 4 = 48,000 IOPS`

   Note: By using Flash Pool technology, we are significantly increasing the performance accelerator. Consult your NetApp sales team for accurate numbers for your environment.

Calculate GB:IOPS Ratio

`115TB ÷ 48,000 IOPS = 2.5GB:1 IOPS`

For every IOPS provisioned, 2.5GB of capacity is provisioned. Likewise, for every 2.5GB of capacity provisioned, 1 IOPS is provisioned. If you extrapolate this to a standard VM HDD size of 60GB, the VM would receive approximately 24 IOPS of performance.

These equations provide a basic understanding of the resource pool sizing. Determining how many VMs can be provisioned is now a matter of simple division.

VM Sizing per Resource Pool

After sizing the four resource pools (compute, memory, storage capacity, and storage performance), you can apply NetApp VM class prescriptions to size VMs per resource pool.

Uncharacterized Workloads on page 5, summarized the required CPU, RAM, storage capacity, and storage performance resources per VM class. Those numbers are now employed to ascertain the number of each VM class that can be hosted according to each of the four resource pools.

CPU

To determine the number of each VM size that can be hosted according to CPU, divide the size of the resource pool by the number of desired vCPUs:

- Small: 1,152 resource pool CPUs ÷ 1 vCPU per VM = 1,152 small VMs
- Medium: 1,152 resource pool CPUs ÷ 2 vCPUs per VM = 576 medium VMs
- Large: 1,152 resource pool CPUs ÷ 4 vCPUs per VM = 288 large VMs
- Extra large: 1,152 resource pool CPUs ÷ 8 vCPUs per VM = 144 extra large VMs

RAM

To determine the number of each VM size that can be hosted according to RAM, divide the size of the pool by the amount of desired RAM:

- Small: 2304GB resource pool RAM ÷ 1GB per VM = 2,304 small VMs
- Medium: 2304GB resource pool RAM ÷ 4GB per VM = 576 medium VMs
- Large: 2304GB resource pool RAM ÷ 12GB per VM = 192 large VMs
- Extra large: 2304GB resource pool RAM ÷ 24GB per VM = 96 extra large VMs

Capacity

To determine the number of each VM size that can be hosted according to storage capacity, divide the size of the pool by the number of desired GB per VM:

- Small: 115TB resource pool capacity ÷ 60GB per VM = 1,962 small VMs
- Medium: 115TB resource pool capacity ÷ 100GB per VM = 1,177 medium VMs
- Large: 115TB resource pool capacity ÷ 500GB per VM = 235 large VMs
- Extra large: 115TB resource pool capacity ÷ 1TB per VM = 115 extra large VMs

Performance

To determine the number of each VM size that can be hosted according to storage performance (IOPS), divide the size of the pool by the number of desired IOPS:

- Small: 48K resource pool IOPS ÷ 25 IOPS per VM = 1,920 small VMs
- Medium: 48K resource pool IOPS ÷ 80 IOPS per VM = 600 medium VMs
- Large: 48K resource pool IOPS ÷ 200 IOPS per VM = 240 large VMs
- Extra large: 48K resource pool IOPS ÷ 400 IOPS per VM = 120 extra large VMs

To determine the maximum number of VMs that can be hosted for each VM class, it is easier to view them in the following table.

> **Note:** Each size is restricted by the smallest number for each different resource pool. For example, a maximum of 192 large VMs can be hosted, because 192 is the smallest number in the large VM row.

Table 4: Maximum VMs hosted per VM class.

VM Class	CPU	RAM	Capacity	Performance
Number of small VMs	1,152	2,304	1,962	1,920
Number of medium VMs	576	576	1,177	600
Number of large VMs	288	192	235	240
Number of extra large VMs	144	96	115	120

Conclusion

Using the described methodology to categorize uncharacterized workloads, you can size your private cloud infrastructure to make sure of sufficient storage capacity and performance, CPU, and memory to support a fully provisioned pod.

However, this is just the first step to getting maximum utilization from your assets. To make sure that you use your system to its full potential, it is essential that you periodically perform cycles of monitoring, adjusting/tuning, verifying that the adjustments were beneficial, and making additional corrective actions. This series of steps, commonly called the Deming Cycle, makes sure that as the resources used by your organization change, so does your policy of allocation and management.

Effective monitoring, which is used for trend analysis, is critical for predicting when resource exhaustion will occur and for preventing shortages. Utilizing tool sets already in place in your organization or products from NetApp, such as NetApp OnCommand® Insight or OnCommand Unified Manager, helps you to observe the current status of the capacity and performance of the equipment and additionally provide long-term statistics for analyzing the effectiveness of your capacity assumptions.

For example, if your assumption during the planning cycle was that your organization would consume approximately 60% small VMs, 20% medium VMs, 15% large VMs, and 5% extra-large VMs, you should validate those assumptions over time. If the ratios are incorrect, you might not be able to host as many VMs as originally planned, or conversely, you might end up with many more VMs, which could affect other areas of your infrastructure and procurement process. Analyzing the data to make sure that the sizing of your service offerings is correct might also assist these processes by proving that your initial sizing assumptions were undersized or oversized, thereby affecting the number of VMs that can be hosted.

Monitoring also plays an important role in determining optimal times for maintenance and batch job scheduling. Using a monitoring system that allows you, the administrator, to view system utilization over a long period of time will facilitate decisions regarding the best time to execute backup jobs and scheduling storage system maintenance with minimal impact.

If your organization uses a bill-back or show-back model for consumption of resources, monitoring is key to making sure that those numbers are accurate and reflect the true utilization by customers. Customers who feel they are being unfairly overcharged are less likely to want to continue using your services. Likewise, if your budget is based on utilization, make sure that every CPU cycle, byte of RAM, and megabyte of disk space is accounted for to make sure that you are not undercharging customers.

Capacity planning is an art based on point-in-time assumptions during the planning phase. To maximize the use of your equipment, you must continually monitor, adjust, and improve the assumptions that were made. This practice not only assists with managing current resources, but also will make sizing the next infrastructure architecture significantly easier because you will have good, reliable data available upon which to base your decisions.

IMT compliance

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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